

## *Polyaminoester and their application in dental compositions*

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### *Technical background*

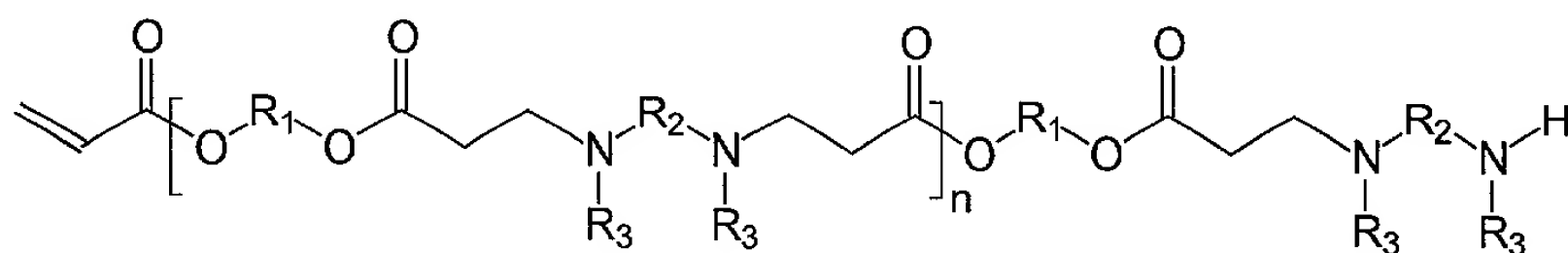
Since some years, the addition polymerization of bisacrylamides and amines is well-known (P. Ferrutti et al., Polymer **26** (1985) 1336). Bisacrylamides are much more stable against hydrolysis compared to acrylic esters. The reaction of amines and esters lead to an transamidation reaction (H.-G. Elias, Makromoleküle, Hüttig&Wepf, Basel, 1990, p.555).

Consequently, the assumption was that a reaction of acrylic esters and amines should lead to an cleavage of ester bonds. Therefore, the formation of addition polymers, prepolymers and macromonomers of amines and acrylic esters should be impossible.

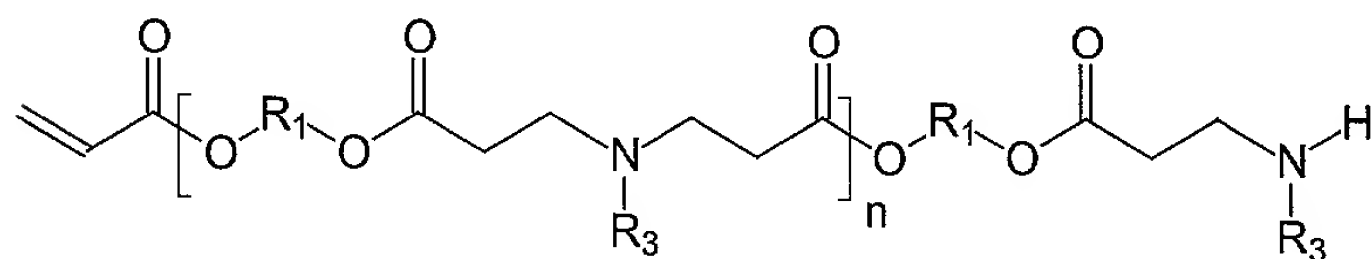
Recently, oligoamido amines and oligoester amines based on antibiotics containing .beta.-lactam rings were investigated (Panayotov, Eur. Polym. J. **32** (1996) 957-962). They were prepared by interaction between ampicillin and amoxicillin and methylenebisacrylamide, 1,4-diacryloylpiperazine and 1,3-propanediol diacrylate.

### *Description of the invention*

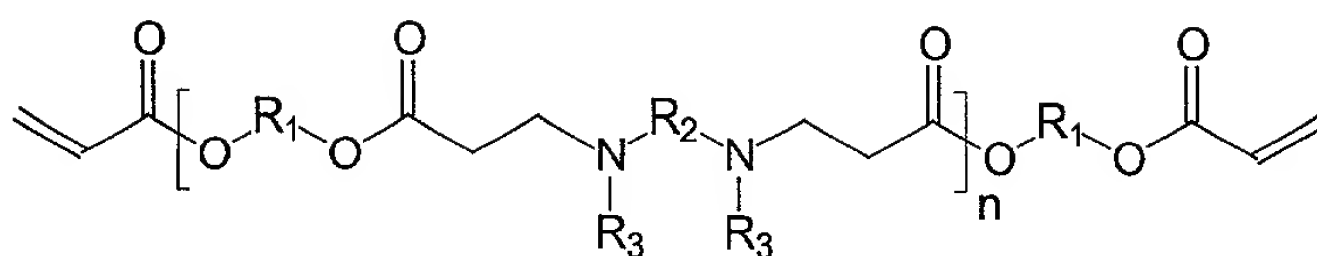
Dental compositions comprising at least a polymerizable monomer and/or at least a polyaminoester of formulas **1** to **6**, pigments, organic and/or inorganic fillers, initiators and stabilizers.



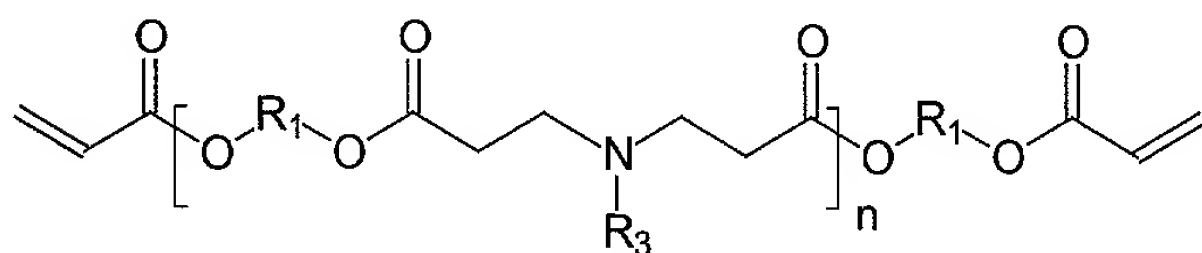
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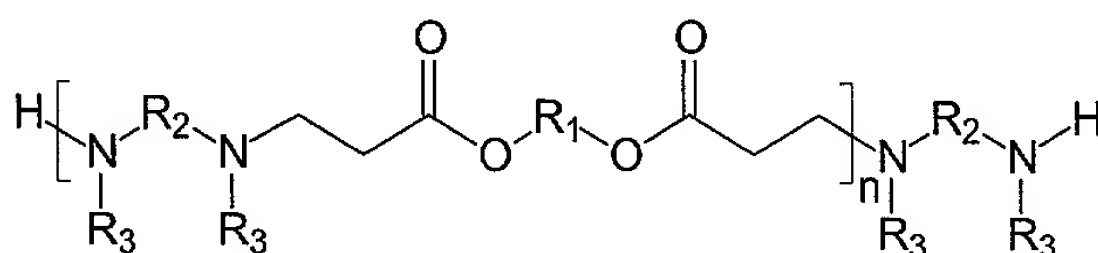
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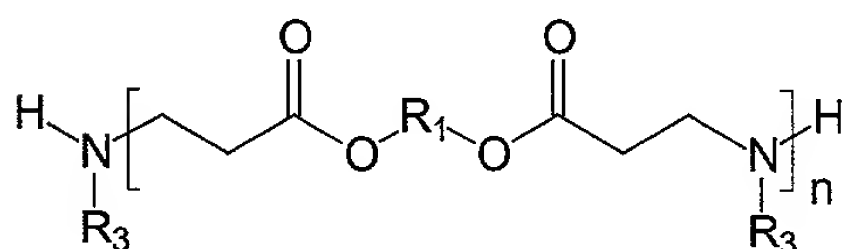
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5 wherein

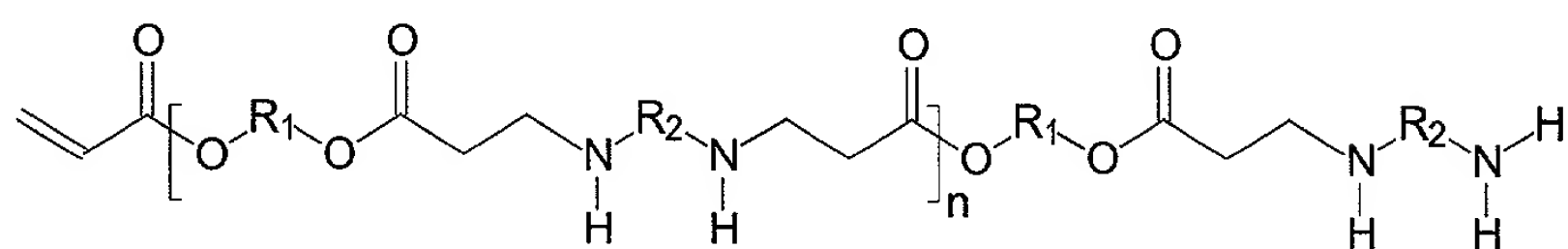
$\text{R}_1$  denotes is a difunctional substituted or unsubstituted  $\text{C}_1$  to  $\text{C}_{18}$  alkylene, difunctional substituted or unsubstituted cycloalkylene, difunctional substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  arylene or heteroarylene, difunctional substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  alkylarylene or alkylheteroarylene, difunctional substituted or unsubstituted  $\text{C}_7$  to  $\text{C}_{30}$  alkylene arylene,

$\text{R}_2$  denotes is a difunctional substituted or unsubstituted  $\text{C}_1$  to  $\text{C}_{18}$  alkylene, difunctional substituted or unsubstituted cycloalkylene, difunctional substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  arylene or heteroarylene, difunctional substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  alkylarylene or alkylheteroarylene, difunctional substituted or unsubstituted  $\text{C}_7$  to  $\text{C}_{30}$  alkylene arylene,

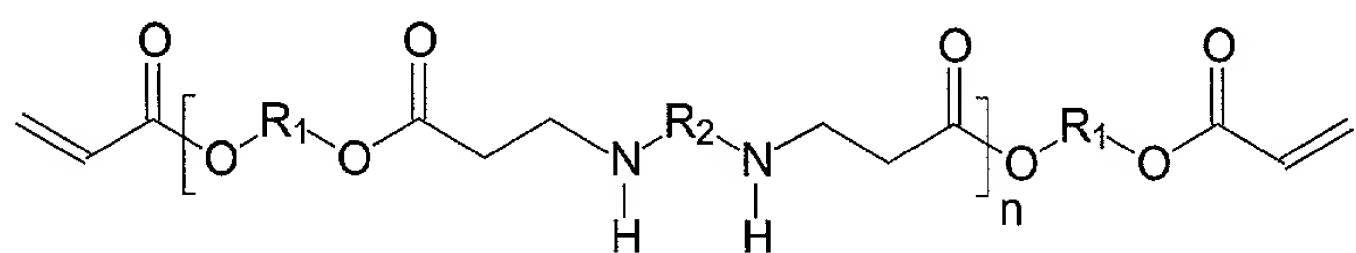
$\text{R}_3$  denotes H or a substituted or unsubstituted  $\text{C}_1$  to  $\text{C}_{18}$  alkylene, substituted or unsubstituted cycloalkylene, substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  arylene or heteroarylene, substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  alkylarylene or alkylheteroarylene, substituted or unsubstituted  $\text{C}_7$  to  $\text{C}_{30}$  alkylene arylene,

$n$  is an integer.

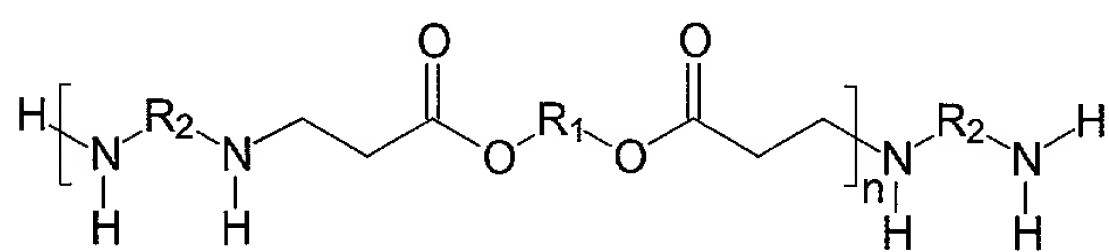
Preferably the invented dental composition contains a polyaminoester that are characterized by the following formulas



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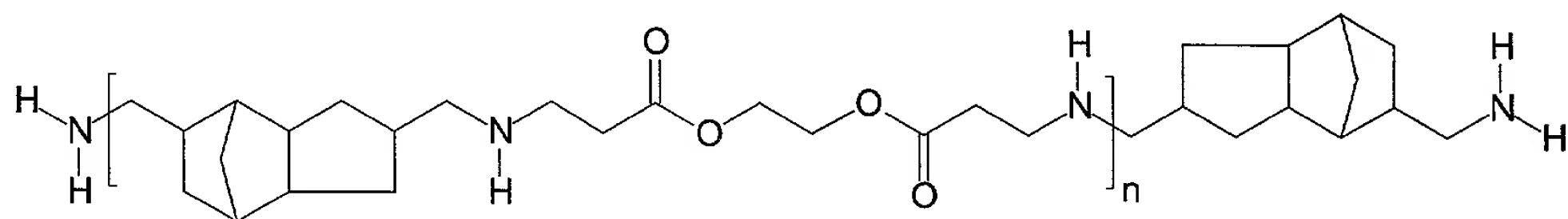
wherein

$\text{R}_1$  denotes is a difunctional substituted or unsubstituted  $\text{C}_1$  to  $\text{C}_{18}$  alkylene, difunctional substituted or unsubstituted cycloalkylene, difunctional substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  arylene or heteroarylene, difunctional substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  alkylarylene or alkylheteroarylene, difunctional substituted or unsubstituted  $\text{C}_7$  to  $\text{C}_{30}$  alkylene arylene,

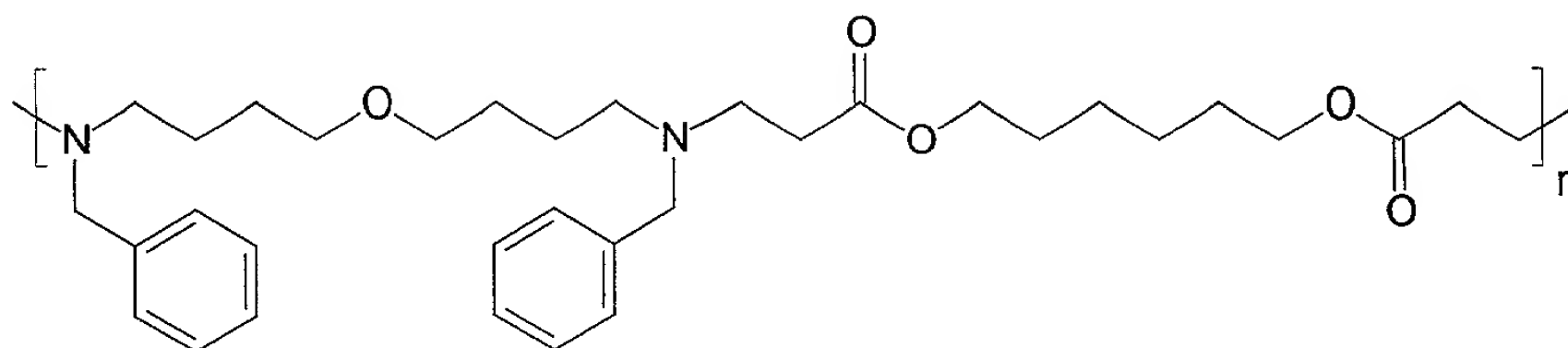
$\text{R}_2$  denotes is a difunctional substituted or unsubstituted  $\text{C}_1$  to  $\text{C}_{18}$  alkylene, difunctional substituted or unsubstituted cycloalkylene, difunctional substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  arylene or heteroarylene, difunctional substituted or unsubstituted  $\text{C}_5$  to  $\text{C}_{18}$  alkylarylene or alkylheteroarylene, difunctional substituted or unsubstituted  $\text{C}_7$  to  $\text{C}_{30}$  alkylene arylene, and

$n$  is an integer.

Most preferably polyaminoesters are applied characterized by the following formulas



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wherein n is an integer.

- 5 Said polymerizable monomer preferably are hydroxyethyl methacrylate, hydroxyethylacrylate, hydroxypropyl methacrylate, ethyleneglykol dimethacrylate, diethyleneglykol dimethacrylate, triethyleneglykol dimethacrylate, 3,(4),8,(9)-Dimethacryloyl-(oxymethyl)-tricyclo-5.2.1.0<sup>2,6</sup> decane, trimethylolpropane triacrylate or trimethylolpropane trimethacrylate, N,N'-dimethylaminoethyl methacrylate.

As fillers are applied inorganic or organic, reactive or nonreactive, surface modified or nonmodified glasses such as polymer granulate or a combination of organic and/or inorganic fillers, strontium aluminosilicate glass, La<sub>2</sub>O<sub>3</sub>, BiPO<sub>4</sub>, ZrO<sub>2</sub>, BaWO<sub>4</sub>, CaWO<sub>4</sub>, SrF<sub>2</sub>, Bi<sub>2</sub>O<sub>3</sub>.

15 Instead of primary monoamine and disubstituted diamines the usage of polyamines is possible, too, leading to crosslinked polyaminoesters.

The invented dental composition preferably is applicable as root canal sealing material or as temporary crown & bridge material.

## 20 Example 1

5.000 g (22.097 mmol) Hexamethylenediacrylate (Servo Delden) and 7.525 g (22.097 mmol) N,N'-Dibenzyl-5-nonandiamin-1,9 were mixed homogeneously and stirred at 60°C for 4 days. After that time a complete conversion was found indicated by disappearance of the double bonds at 1635 / 1619 cm<sup>-1</sup>.

Yield: 12.525 g (100 % of th.)

(C<sub>34</sub>H<sub>50</sub>N<sub>2</sub>O<sub>5</sub>)<sub>n</sub>, (566.8)<sub>n</sub>

[η] = 8.57 ml/g (Viscosity in THF solution)

IR: 2920 / 2865 (CH<sub>2</sub>), 1735 (CO)

$M_n$  (GPC) = 2225 (4661) g/mol

$M_w$  (GPC) = 9398 (10200) g/mol

### Example 2

5            20.000 g (88.39 mmol) Hexamethyldiacrylate (Servo Delden) and  
15.719 g (106.07 mmol) 3,6-Dioxaoctan-diamin-1,8 (Fluka) were mixed  
homogeneously and stirred at room temperature for 1.5 hours. After that time a  
complete conversion was found indicated by disappearance of the double bonds  
at 1635 / 1619  $\text{cm}^{-1}$ .

10    Yield: 35.719 g (100 % of th.)

$(\text{C}_{18}\text{H}_{34}\text{N}_2\text{O}_6)_n$ , (347.5)<sub>n</sub>

$\eta = 4.73 \pm 0.05 \text{ Pa}\cdot\text{s}$  (dynamic viscosity measured using Bohlin CS50 rheometer)

IR: 3325 (NH), 2920 / 2865 ( $\text{CH}_2$ ), 1735 (CO)

$^{13}\text{C}$ -NMR ( $\text{CDCl}_3$ ): 172.6/172.4 (6), 73.4 (2); 70.5/70.2 (3); 64.2 (7), 49.8 (1), 45.0

15    (4), 41.7 (4), 34.8 (5), 28.4 (8), 25.5 (9)

IR: 3325 (NH), 2920 / 2865 ( $\text{CH}_2$ ), 1735 (CO)

### Example 3

10.000 g (58.77 mmol) Ethylene glycol diacrylate and 14.125 g (58.77  
20 mmol) N,N'-Dibenzylethylenediamine were mixed homogeneously and stirred at  
room temperature for 40 hours at 60°C. After that time a complete conversion  
was found indicated by disappearance of the double bonds at 1635 / 1619  $\text{cm}^{-1}$ .

Yield: 24.125 g (100 % of th.)

$\eta = 1557 \pm 17 \text{ Pa}\cdot\text{s}$  (dynamic viscosity measured using Bohlin CS50 rheometer)

25     $[\eta] = 9.176 \text{ ml/g}$  (viscosity in THF solution)

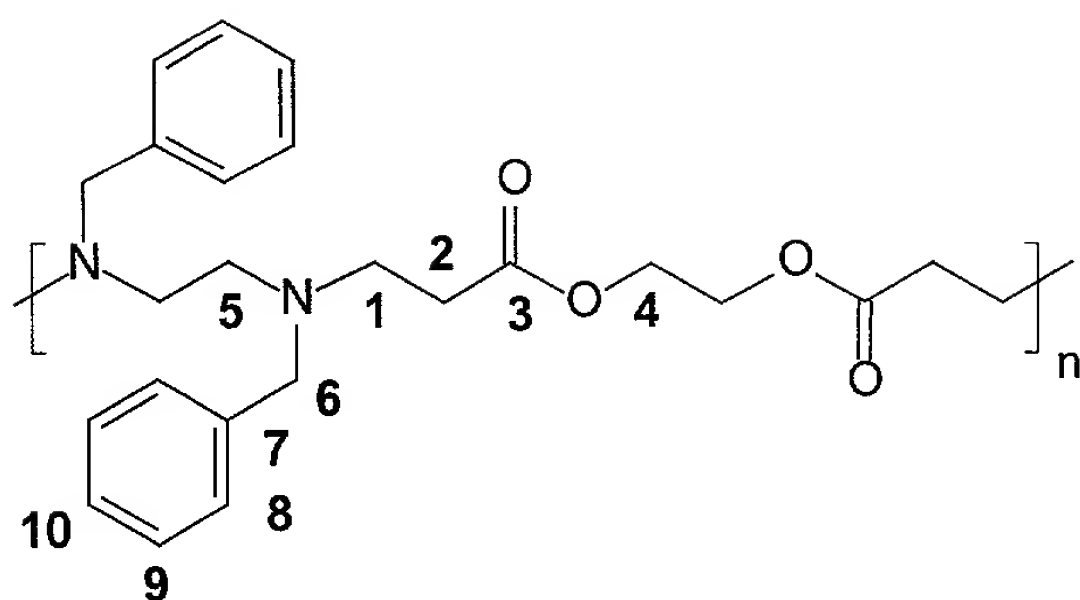
$M_n$  (GPC) = 1575 g/mol

$M_w$  (GPC) = 10060 g/mol

$(\text{C}_{24}\text{H}_{32}\text{N}_2\text{O}_4)_n$ , (410.5)<sub>n</sub>

IR: 3060 / 3028; 2953 / 2816 ( $\text{CH}_2$ ), 1743 (CO)

30     $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 49.7 (1), 32.4 (2), 172.6 (3), 621.0 (4), 51.5 (5), 58.6 (6), 139.2  
(7), 128.6 (8), 128.0 (9), 126.8 (10)



#### Example 4

10.000 g (58.77 mmol) Ethylene glykol diacrylate and 20.012 g (58.77 mmol) N,N'-Dibenzyl-5-oxanonane diamine-1.9 were mixed homogeneously and stirred at room temperature for 40 hours at 60°C. After that time a complete conversion was found indicated by disappearance of the double bonds at 1635 / 1619 cm<sup>-1</sup>.

Yield: 30.012 g (100 % of th.)

10  $\eta = 188.8 \pm 1.3$  Pa\*s (dynamic viscosity measured using Bohlin CS50 rheometer)

$[\eta] = 10.051$  ml/g (viscosity in THF solution)

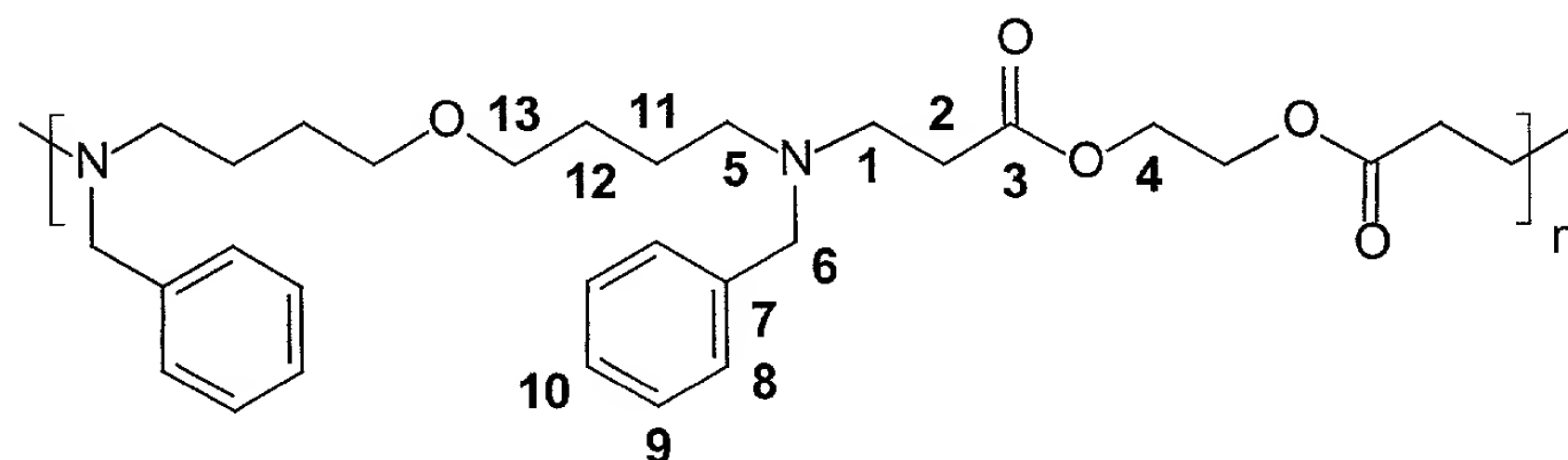
$M_n$  (GPC) = 4281 g/mol

$M_w$  (GPC) = 12110 g/mol

$(C_{30}H_{42}N_2O_5)_n$ , (510.7)<sub>n</sub>

15 IR: 3060 / 3026 / 2943 / 2860 / 2802 (CH<sub>2</sub>), 1740 / 1731 (CO)

<sup>13</sup>C NMR (CDCl<sub>3</sub>): 49.1 (1), 32.4 (2), 172.3 (3), 62.1 (4), 53.2 (5), 58.2 (6), 139.5 (7), 128.0 (8), 127.9 (9), 126.7 (10), 27.5 (11), 23.5 (12)



#### 20 Example 5

10.000 g (58.77 mmol) Ethylene glykol diacrylate and 11.420 g (58.77 mmol) N,N'-Dibenzyl-4,4'-dicyclohexylmethane were mixed homogeneously and

stirred at room temperature for 40 hours at 60°C. After that time a complete conversion was found indicated by disappearance of the double bonds at 1635 / 1619 cm<sup>-1</sup>.

Yield: 21.420 g (100 % of th.)

5 IR: 3060 / 3026 / 2943 / 2860 / 2802 (CH<sub>2</sub>), 1740 / 1731 (CO)

### Example 6

10.000 g (58.77 mmol) Ethylene glykol diacrylate and 5.710 g (29.384 mmol) 3,(4),8,(9)-Bis(aminomethyl)-tricyclo-5.2.1.0<sup>2,6</sup> decane were mixed  
10 homogeneously and stirred at room temperature for 2 hours at room temperature. After that time a complete conversion was found indicated by disappearance of the double bonds at 1635 / 1619 cm<sup>-1</sup>.

Yield: 15.710 g (100 % of th.)

$\eta$  = Pa\*s (dynamic viscosity measured using Bohlin CS50 rheometer)

15 (C<sub>28</sub>H<sub>42</sub>N<sub>2</sub>O<sub>8</sub>)<sub>n</sub>, (534.7)<sub>n</sub>

IR: 3445 / 3332 (NH), 2947 / 2875 / 2821(CH<sub>2</sub>), 1729 (CO); 1637 / 1619 (C=C)

### Example 7

10.000 g (58.77 mmol) Ethylene glykol diacrylate and 22.840 5.710 g  
20 (117.54 mmol) 3,(4),8,(9)-Bis(aminomethyl)-tricyclo-5.2.1.0<sup>2,6</sup> decane were mixed homogeneously and stirred at room temperature for 2 hours at room temperature. After that time a complete conversion was found indicated by disappearance of the double bonds at 1635 / 1619 cm<sup>-1</sup>.

Yield: 32.840 g (100 % of th.)

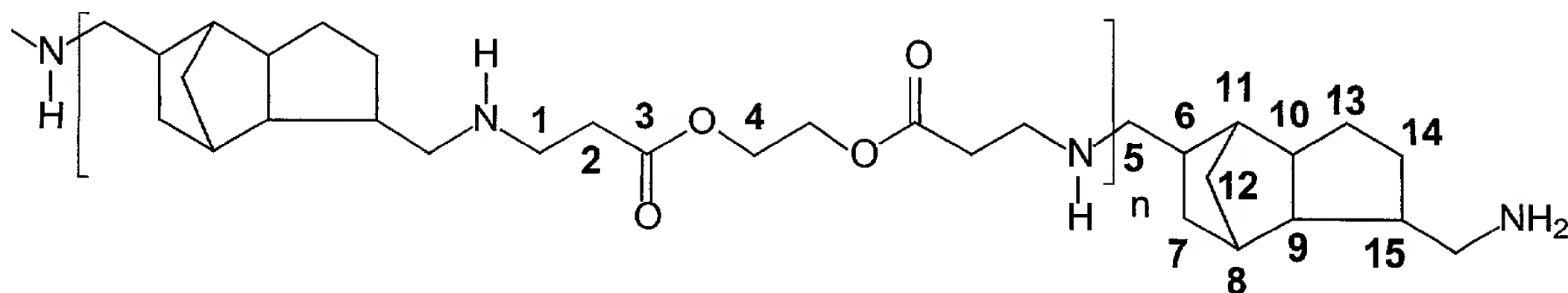
25  $\eta$  = 218800 ± 1990 Pa\*s (dynamic viscosity measured using Bohlin CS50 rheometer)

(C<sub>32</sub>H<sub>54</sub>N<sub>4</sub>O<sub>4</sub>)<sub>n</sub>, (558.8)<sub>n</sub>

IR: 3373 / 3286 (NH), 2960 / 2888 (CH<sub>2</sub>), 1743 / 1731 (CO)

<sup>13</sup>C NMR (CDCl<sub>3</sub>): 47.5 (1), 34.3/34.7 (2), 172.9 (3), 66.0 (4), 55.3 (5), signals of

30 (6) to (15) between 24.5 and 63.5 ppm



### Example 8

5 To 10.000 g (58.77 mmol) Ethylene glykol diacrylate dissolved in 50 ml THF were slowly added at 0 to 5°C under stirring a solution of 8.709 g (58.77 mmol) 3,6-Dioxaoctane diamine-1,8 in 50 ml THF. After adding the amine the solution was stirred at room temperature for 1.5 hours. After that time a complete conversion was found due to the disappearance of the double bonds at 1635 / 1619 cm<sup>-1</sup>. Then the solvent was removed and the addition polymer was dried in vacuum.

Yield: 18.709 g (100 % of th.)

$\eta$  = Pa\*s (dynamic viscosity measured using Bohlin CS50 rheometer)

(C<sub>14</sub>H<sub>26</sub>N<sub>2</sub>O<sub>6</sub>)<sub>n</sub>, (318.4)<sub>n</sub>

15 IR: 3373 / 3286 (NH), 2960 / 2888 (CH<sub>2</sub>), 1743 / 1731 (CO)

### Application Example 1 (Dental root canal sealer)

#### Paste A

20 8.404 g (37.14 mmol) Hexamethylendiacylate (Servo Delden), 25.968 g CaWO<sub>4</sub>, 6.492 g ZrO<sub>2</sub> and 0.325 g aerosil were mixed homogeneously.

#### Paste B

25 7.217 g (37.14 mmol) 3,(4),8,(9)-Bis(aminomethyl)-tricyclo-5.2.1.0<sup>2,6</sup> decane, 28.867 g CaWO<sub>4</sub>, 7.217 g ZrO<sub>2</sub> and 0.722 g aerosil were mixed homogeneously.



### Dental root canal sealer

Immediately before use 0.214 g of Paste A and 0.200 g of Paste B were mixed homogeneously. The setting time of the root canal sealing material is 30 minutes. The radiopacity of 12.8 mm/ mm Al.

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### Application Example 2 (Dental root canal sealer)

#### Paste A

2.5213 g (11.14 mmol) Hexamethylenediacrylate (Servo Delden), 12.9298 g  $\text{CaWO}_4$ , 3.2325 g  $\text{ZrO}_2$  and 0.0385 g aerosil were mixed homogeneously.

#### Paste B

0.801 g (5.29 mmol) 1-Aminoadamantane, 1.802 g (5.29 mmol) N,N'-Dibenzyl-5-oxanonandiamin-1,9, 0.103 g (0.53 mmol) 3,(4),8,(9)-Bis(aminomethyl)-tricyclo-5.2.1.0<sup>2,6</sup> decane, 10.411 g  $\text{CaWO}_4$ , 2.603 g  $\text{ZrO}_2$  and 0.315 g aerosil were mixed homogeneously.

### Dental root canal sealer

Immediately before use 0.173 g of Paste A and 0.200 g of Paste B were mixed homogeneously. The setting time of the root canal sealing material is 30 minutes. The radiopacity of 13.8 mm/ mm Al.